Low Impact Development Practices
AutoCASE Evaluation with Pima County and the City of Tucson

John C. Parker & Ryan Meyers, Impact Infrastructure, LLC

16th-17th April 2014
Summary of Information Needed

DATA DISCUSSION
Assumptions

• 1,000 square feet (.02296 acres)
• 18,856 cubic feet capacity
• Input in model as “Infiltration Basin”
• Expected Capital Expenditure (CapEx) cost of $5,171/acre
• Annual O&M cost expected at $21/acre/year
• Residual capacity of basin – empty/negligible

Data Required

• None
Bio Retention Basin

Assumptions

- 1,000 square feet (.02296 acres)
- CapEx expected at $68,519/acre
- Annual O&M cost at $1,179/acre/year

Data Required

- None
Xeriscape Swale

Assumptions

• 1,000 square feet (.02296 acres)
• Expected CapEx cost of $16,982/acre
• Annual O&M cost expected at $540/acre

Data Required

• None
Cisterns

Assumptions

• Sewer fee not applicable

Data Required

• Capital expenditure and expected O&M costs – Tucson to provide from Water Program. Ryan and Tucson to check and vendor specs.
• Flow rate out of cistern and percent of time in use – Tucson to provide - check appendix to commercial rainwater harvesting ordinance
Infiltration Trench

**Assumptions**
- 1,000 square feet (.02296 acres)
- Expected CapEx cost of $117,221/acre
- Annual O&M cost expected at $518/acre

**Data Required**
- None
Assumptions

• 1000 square feet (.02296 acres)
• 45,345 cubic feet capacity
• Expected CapEx cost of $54,352/acre
• Annual O&M cost expected at $614/acre
• Residual capacity of basin – empty/negligible

Data Required

• None
Pervious Pavers/Pavement

Assumptions

• 1,000 square feet (.02296 acres)
• Expected CapEx cost of $199,172/acre
• Annual O&M cost expected at $2614/acre

Data Required

• None – but Irene will contact Sam regarding porous paver costs
Curb Extensions

Data Required

• Accident rates on relevant streets (or type of street) – Josh to provide
• Accident damage extent – Josh to provide
• Area/size of vegetated space of average chicane/curb extension.
Other Assumptions & Requirements

Activity Value
- Expected number of users of bike lanes
- Expected user-miles traveled on bike lanes
- Expected division between cyclists and pedestrians (walking/running)

Tree Benefits
- Expected number of trees planted
  - Diameter at breast height (D.B.H.) of trees – assumed to be 2”
  - Lifespan average 25 years (max. 40 years)
- Estimated fraction of tree shading over pavement will be taken from drawings
- Ii will check energy savings from iTree

Water Costs
- Assumed to be water costs associated with irrigation reduction/potable water savings, and water pumping costs. ii will research social cost of water
RESULTS
Meeting Purpose

- Make sure we are on the right track
- Confirm assumptions and data
- Identify missing information
- Share preliminary results for individual Green Infrastructure (GI)/Low Impact Development (LID) Practices
- Identify areas for further investigation or changes required in preliminary results
- Confirm next stage analysis – Rio Verde Village and Silverbell Road sites analysis
- AutoCASE Beta demo
- Flood model demo (in Envision Business Case Evaluator)
Preliminary Evaluation

GREEN INFRASTRUCTURE/LOW IMPACT DEVELOPMENT PRACTICES
GI/LID Practices

- Water Harvesting Basins
- Bio Retention Basin
- Xeriscape Swale
- Cistern
- Infiltration Trench
- Detention Basins (or Extended Detention Basins)
- Pervious Pavers
- Curb Extensions (new and retrofit chicanes, medians, traffic circles and road diets with inlets to gather streetwater)
GI/LID Practices & Sites

- Rio Verde Village
  - Water Harvesting Basins
  - Bio Retention Basin
  - Cistern
  - Pervious Pavers
  - Detention Basins (or Extended Detention Basins)

- Silverbell Road
  - Water Harvesting Basins
  - Infiltration Trench
  - Curb Extensions (new and retrofit chicanes, medians, traffic circles and road diets with inlets to gather streetwater)

- Xeriscape Swale?
Rio Verde Village
Rio Verde Village
Rio Verde Village
Silverbell Road
Silverbell Road – Section 1
Silverbell Road – Section 2
Silverbell Road – Section 4
Silverbell Road
Silverbell Road
Sustainable NPV for GI/LID Features Analyzed To Date*

*Some features to be updated with missing information

$Net Present Value per 1,000 ft^2
Sustainable NPV for GI/LID

Features Analyzed To Date*

*Some features to be updated with missing information

<table>
<thead>
<tr>
<th>Feature</th>
<th>Square Feet</th>
<th>Equivalent Acres</th>
<th>Max Volume Capacity</th>
<th>CapEx Cost</th>
<th>O&amp;M Costs</th>
<th>Flood Risk Reduction</th>
<th>Property Value Uplift</th>
<th>Heat Mortality Risk Reduction</th>
<th>Reduced CO2 Emissions</th>
<th>Reduced Irrigation Costs</th>
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<td>$ 575</td>
<td>$ 51</td>
<td>$ 508</td>
<td>$ 1,344</td>
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<td>$ 13,029</td>
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</tbody>
</table>

*Entered as Infiltration Basin
Preliminary Results

RESULTS BY GI/LID FEATURE
Concrete

Assumptions
- 1,000 square feet
- Concrete 1 foot thick
- 150 pounds of concrete per cubic foot (0.075 short tons/cubic ft)
- $14.16/cubic foot ($12.00 in 2006 USD) (Source)
- Annual O&M costs of $0

<table>
<thead>
<tr>
<th></th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
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<tr>
<td>Heat Mortality</td>
<td></td>
<td></td>
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<tr>
<td>CO2 Emissions</td>
<td>-$1,344</td>
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</table>
Concrete

Percent of Results Achieving a Lower NPV

- Sustainable NPV
- Direct Financial NPV

Thousands

$-(45) - (40) - (35) - (30) - (25) - (20) - (15) - (10) - (5) - $
Water Harvesting Basin

- A depressed area that captures and infiltrates stormwater

<table>
<thead>
<tr>
<th></th>
<th>Square Feet (ft²)</th>
<th>Acres</th>
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<td>25,141</td>
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Water Harvesting Basin
# Water Harvesting Basin

<table>
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<tr>
<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
<th>F-NPV</th>
<th>S-NPV</th>
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<td>-$9</td>
<td>$137</td>
<td>$16</td>
<td>$380</td>
<td>$1,308</td>
<td>$13,007</td>
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<td>50%</td>
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<td>-$7</td>
<td>$350</td>
<td>$53</td>
<td>$503</td>
<td>$1,345</td>
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*Per thousand square feet, relative to grey option (concrete)*
Water Harvesting Basin

Percent of Results Achieving a Lower NPV

- F-NPV
- S-NPV
AutoCASE LID/GI Business Case Evaluation

Water Harvesting Basin

<table>
<thead>
<tr>
<th>Project Division of Benefits</th>
<th>Project Division of Costs</th>
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<tbody>
<tr>
<td>Heat Stress Mortality</td>
<td>Heed Expenditures</td>
</tr>
<tr>
<td>Flood Risk Value</td>
<td>O&amp;M Costs</td>
</tr>
<tr>
<td>Change in Property Values - Resident Portion</td>
<td>Change in Property Values - Gov's Portion</td>
</tr>
</tbody>
</table>
Water Harvesting Basin

Total NPV of Project for each Envision™ Category

- Quality of Life: $250.00
- Leadership: $50.00
- Resource Allocation: $50.00
- Natural World: $50.00
- Climate: $350.00
- Other: $50.00
Bio Retention Basin

- A depressed area with a constructed soil media that captures stormwater and may also contain underdrains to enhance infiltration

<table>
<thead>
<tr>
<th></th>
<th>Square Feet (ft²)</th>
<th>Acres</th>
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<tbody>
<tr>
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<tr>
<td></td>
<td>153</td>
<td>0.00351</td>
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<tr>
<td></td>
<td>99</td>
<td>0.00227</td>
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<tr>
<td></td>
<td>297</td>
<td>0.00682</td>
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<tr>
<td></td>
<td>1,931</td>
<td>0.04433</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>2,777</strong></td>
<td><strong>0.06375</strong></td>
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Bio Retention Basin
## Bio Retention Basin

*Per thousand square feet, relative to grey option (concrete)*

<table>
<thead>
<tr>
<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
<th>F-NPV</th>
<th>S-NPV</th>
</tr>
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<tbody>
<tr>
<td>10%</td>
<td>$10,122</td>
<td>-$465</td>
<td>$117</td>
<td>$16</td>
<td>$375</td>
<td>$1,308</td>
<td>$9,721</td>
<td>$11,958</td>
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<tr>
<td>50%</td>
<td>$11,005</td>
<td>-$368</td>
<td>$285</td>
<td>$52</td>
<td>$496</td>
<td>$1,345</td>
<td>$10,642</td>
<td>$12,961</td>
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<tr>
<td>90%</td>
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<td>-$295</td>
<td>$961</td>
<td>$88</td>
<td>$646</td>
<td>$1,379</td>
<td>$11,444</td>
<td>$13,988</td>
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This table represents the cost and benefits of bioretention basins at different percentiles. The data includes capital expenditure (CapEx), operational and maintenance (O&M), flood risk, property value, heat mortality, CO2 emissions, and Net Present Value (NPV) metrics (F-NPV and S-NPV) for different conditions.
Bio Retention Basin

Percent of Results Achieving a Lower NPV

- F-NPV
- S-NPV

0% 20% 40% 60% 80% 100%

$0 $5,000 $10,000 $15,000 $20,000 $25,000 $30,000 $35,000

Pima/Tucson GI/LID Stormwater Management Business Case Review
Bio Retention Basin

Project Division of Benefits
- Flood Risk Value
- Change in Property Values - Resident Portion
- Change in Property Values - Gov's Portion
- Heat Stress Mortality

Project Division of Costs
- O&M Costs
- Capital Expenditures
Bio Retention Basin

Total NPV of Project for each Envision™ Category

- Quality of Life
- Leadership
- Resource Allocation
- Natural World
- Climate
- Other

[$0.00, $50.00, $100.00, $150.00, $200.00, $250.00, $300.00, $350.00]
Xeriscape Swale

- A depressed conveyance feature for transporting and infiltrating stormwater. Swales may contain check-dams or weirs to slow the flow of water and encourage infiltration.
Xeriscape Swale
## Xeriscape Swale

<table>
<thead>
<tr>
<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
<th>F-NPV</th>
<th>S-NPV</th>
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<tbody>
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<td>-$222</td>
<td>$124</td>
<td>$19</td>
<td>$388</td>
<td>$1,308</td>
<td>$12,531</td>
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<tr>
<td>50%</td>
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<td>$323</td>
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<td>$499</td>
<td>$1,345</td>
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<tr>
<td>90%</td>
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<td>$88</td>
<td>$657</td>
<td>$1,379</td>
<td>$12,987</td>
<td>$15,757</td>
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</tbody>
</table>

*Per thousand square feet, relative to grey option (concrete)*
Xeriscape Swale

Percent of Results Achieving a Lower NPV

- F-NPV
- S-NPV

Pima/Tucson GI/LID Stormwater Management Business Case Review
Xeriscape Swale

**Project Division of Benefits**
- Heat Stress Mortality
- Flood Risk Value
- Change in Property Values - Resident Portion
- Change in Property Values - Gov's Portion

**Project Division of Costs**
- O&M Costs
- Capital Expenditures
Xeriscape Swale

Total NPV of Project for each Envision™ Category

- Quality of Life: $350.00
- Leadership: $50.00
- Resource Allocation: $50.00
- Natural World: $50.00
- Climate: $300.00
- Other: $0.00

Pima/Tucson GI/LID Stormwater Management Business Case Review
Cisterns

- A rigid device of metal, plastic or other solid material that captures and stores water from an impervious surface. It can also be rigged to supply irrigation to the site by a simple hose bib or a complex automatic pumping and PVC piping system.
Cisterns

Notes: Cautionary signage and locking features

Clear and obvious signage should be provided whenever harvested rainwater is used. Signs should read: Caution: Non-Potable Water. Do Not Drink or Similar in English and Spanish. Areas where signage is recommended include entrances to rooms (including mechanical rooms) where harvested water is piped or used, irrigation and automobile washing hoses, low-flow outlet orifices, toilet tanks that use harvested water for flushing, and any spigots, draindown pipes, or access hatches.

All valves (except fixture supply control valves) should be equipped with locking features.

Pima/Tucson GI/LID Stormwater Management Business Case Review
Cisterns

Assumptions

• Max capacity of 780 cubic feet (5,834.4 gallons)
• 70% residual capacity (30% full) before large storm (conservative) – to be revised
• CapEx cost estimated at $3,000-$5,000 / cistern
• O&M costs unknown, set at $0
• Flow rate out of cistern (to be revised) at 1 ounce per second, flowing
  • Low: 15% of the time
  • Expected: 30% of the time
  • High: 45% of the time
• Water used for irrigation purposes
• Service fee = $0 (already paid on site for other use)
• Cost of potable water: $2.22/CCF (Commercial Rate, http://www.tucsonaz.gov/water/rates/potable)
# Cisterns

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<tr>
<th>Percentile</th>
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<td>$ 33</td>
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<td>-$ 723</td>
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<td>$</td>
<td>$ 3,955</td>
<td>$ 87</td>
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<td>$</td>
<td>$ 5,205</td>
<td>$ 229</td>
<td>$ 1,520</td>
<td>$ 1,654</td>
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Cisterns

Percent of Results Achieving a Lower NPV

- $2,000 - $1,000 - $0 $1,000 $2,000 $3,000 $4,000 $5,000

F-NPV
S-NPV
Infiltration Trench

- An excavated trench that has been backfilled with porous material that captures and infiltrates stormwater.
Infiltration Trench

NOTE: ENSURE THAT SUBGRADE COMPACTION IS MINIMIZED DURING CONSTRUCTION. SCARIFY OR RIP SUBGRADE TO A DEPTH OF 9”–12”
# Infiltration Trench

<table>
<thead>
<tr>
<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
<th>F-NPV</th>
<th>S-NPV</th>
</tr>
</thead>
<tbody>
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<td>$128</td>
<td>$16</td>
<td>$372</td>
<td>$1,308</td>
<td>$9,564</td>
<td>$11,786</td>
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<td>$51</td>
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<td>$667</td>
<td>$1,379</td>
<td>$11,587</td>
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*Per thousand square feet, relative to grey option (concrete)*
Infiltration Trench

Percent of Results Achieving a Lower NPV

- F-NPV
- S-NPV
Infiltration Trench

Project Division of Benefits

- Heat Stress Mortality
- Change in Property Values - Resident Portion
- Flood Risk Value

Project Division of Costs

- Capital Expenditures
- O&M Costs
- Change in Property Values - Gov’t Portion
Infiltration Trench

**Total NPV of Project for each Envision™ Category**

- **Quality of Life**: $250.00
- **Leadership**: $50.00
- **Resource Allocation**: $50.00
- **Natural World**: $50.00
- **Climate**: $350.00
- **Other**: $50.00

Pima/Tucson GI/LID Stormwater Management Business Case Review
Detention Basin/Extended Detention

- Dry detention ponds (a.k.a. dry ponds, extended detention basins, detention ponds, extended detention ponds) are basins whose outlets have been designed to detain stormwater runoff for some minimum time (e.g., 24 hours) to allow particles and associated pollutants to settle. Unlike wet ponds, these facilities do not have a large permanent pool of water. However, they are often designed with small pools at the inlet and outlet of the basin. They can also be used to provide flood control by including additional flood detention storage.

- EPA NPDES

<table>
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<tr>
<th></th>
<th>Square Feet (ft²)</th>
<th>Acres</th>
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<td>Extended Detention</td>
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<tr>
<td>Total</td>
<td>15,115</td>
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(Extended) Detention Basin

Example profile view of a dry pond design.
## Detention Basin/Extended Detention

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<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
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<td>$140</td>
<td>$16</td>
<td>$376</td>
<td>$1,308</td>
<td>$11,627</td>
<td>$13,790</td>
</tr>
<tr>
<td>50%</td>
<td>$12,082</td>
<td>-$188</td>
<td>$355</td>
<td>$50</td>
<td>$503</td>
<td>$1,345</td>
<td>$11,879</td>
<td>$14,155</td>
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<tr>
<td>90%</td>
<td>$12,313</td>
<td>-$113</td>
<td>$1,135</td>
<td>$87</td>
<td>$653</td>
<td>$1,379</td>
<td>$12,129</td>
<td>$15,003</td>
</tr>
</tbody>
</table>

*Per thousand square feet, relative to grey option (concrete)*
Detention Basin

Percent of Results Achieving a Lower NPV

- $0
- $10,000
- $20,000
- $30,000
- $40,000
- 0%
- 20%
- 40%
- 60%
- 80%
- 100%

F-NPV
S-NPV
Detention Basin

Project Division of Benefits

- Heat Stress Mortality
- Change in Property Values - Gov's Portion
- Change in Property Values - Resident Portion
- Flood Risk Value

Project Division of Costs

- Capital Expenditures
- O&M Costs
Detention Basin

Total NPV of Project for each Envision™ Category

- Quality of Life: $250.00
- Leadership: $50.00
- Resource Allocation: $50.00
- Natural World: $50.00
- Climate: $350.00
- Other: $0.00
Pervious Pavers/Pavement

- Pavements that allow water to infiltrate, thus changing an impervious stormwater source to a stormwater sink.

<table>
<thead>
<tr>
<th></th>
<th>Square Feet (ft²)</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Porous Pavement</td>
<td>1,263</td>
<td>0.02900</td>
</tr>
<tr>
<td></td>
<td>1,437</td>
<td>0.03300</td>
</tr>
<tr>
<td></td>
<td>1,481</td>
<td>0.03400</td>
</tr>
<tr>
<td>Total</td>
<td>4,182</td>
<td>0.09600</td>
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</table>
Pervious Pavers/Pavement

NOTES:
INTERNAL OVERFLOW SHOULD BE PROVIDED FOR PERMEABLE INTERLOCKING CONCRETE PAVERS TO PREVENT DISLODGING AND TRANSPORT OF JOINT FILL MATERIAL BY UPWELLING WATER. PERMEABLE CONCRETE MAY BYPASS AT THE SURFACE WHEN FULL.

Pima/Tucson GI/LID Stormwater Management Business Case Review 69
# Pervious Pavers/Pavement

<table>
<thead>
<tr>
<th>Percentile</th>
<th>CapEx Cost</th>
<th>O&amp;M</th>
<th>Flood Risk</th>
<th>Property Value</th>
<th>Heat Mortality</th>
<th>CO2 Emissions</th>
<th>F-NPV</th>
<th>S-NPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>-$ 2,535</td>
<td>-$ 1,058</td>
<td>$ 24</td>
<td>$ 17</td>
<td>$ -</td>
<td>$ -</td>
<td>-$ 3,588</td>
<td>-$ 3,419</td>
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<tr>
<td>50%</td>
<td>-$ 2,499</td>
<td>-$ 832</td>
<td>$ 83</td>
<td>$ 53</td>
<td>$ -</td>
<td>$ -</td>
<td>-$ 3,333</td>
<td>-$ 3,168</td>
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<tr>
<td>90%</td>
<td>-$ 2,460</td>
<td>-$ 660</td>
<td>$ 320</td>
<td>$ 86</td>
<td>$ -</td>
<td>$ -</td>
<td>-$ 3,130</td>
<td>-$ 2,926</td>
</tr>
</tbody>
</table>

*Per thousand square feet, relative to grey option (pavement)*

- Note – heat mortality to be added to benefits.
Pervious Pavers/Pavement

Note: “Grey” alternative given as asphalt; Capital Expenditure costs relative to asphalt costs. Source
Pervious Pavers/Pavement

- Note – heat mortality to be added to benefits.
Pervious Pavers/Pavement

- Note – heat mortality to be added to benefits.
Curb Extensions

- New and retrofit chicanes, medians, traffic circles and road diets with inlets to gather streetwater
Harvesting Basin/Chicane
Web and AutoCAD Civil 3D Versions

AUTOCASE BETA DEMO
Envision Business Case Evaluator

FLOOD MODEL
Next Steps

TO DO/TO DISCUSS
*Maintenance and Storm Sewer System costs were removed from Total before being converted to 2014 dollars and input into AutoCASE.
Sent from Evan Canfield on March 3, 2014. [Back to Pervious Pavers](#)